National Centers for Coastal Ocean Science

Accomplishments Report

FY 2002

"Science Serving Communities"

National Centers for Coastal Ocean Science
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

Welcome:

The National Centers for Coastal Ocean Science (NCCOS), as a young organization, continues to explore how best to communicate with our customers, partners, and stakeholders on the many scientific products and services we provide for preserving our country's extraordinary coastal ocean resources. This first yearly accomplishments report outlines some of the important science-related activities NCCOS scientists and partners have been working on.

In NCCOS's third full year, expanding partnerships led to more and more valuable scientific advances to meet the needs of coastal communities. The multi-disciplinary partnership represented at NCCOS's new Hollings Marine Laboratory, in Charleston, S.C., is already showing the way for protection of coastal resources and human health. This broad partnership – involving NCCOS, the South Carolina Department of Natural Resources, the University of Charleston, the Medical University of South Carolina, and the National Institute of Standards and Technology – brings extensive expertise, resources and creativity to helping protect and restore coastal ecosystems and reduce risks to those depending on those ecosystems for their well being.

NCCOS's 2002 advances in ecological forecasting are helping managers better understand, predict, and manage impacts of chemical, biological, and physical risks to ocean coastal environments and populations. Whether forecasting the potential landfall of a harmful algal bloom or the prospects for the coming season's pink shrimp harvests, this exciting new capability holds great promise for coastal managers for years to come.

With its "Science Serving Coastal Communities", NCCOS and our 100-plus partner organizations are undertaking new initiatives in ocean, coastal, and Great Lakes science. *Our constant focus*: to move these scientific advances beyond the laboratory and into the day-to-day needs of coastal managers and coastal populations nationwide.

That focus – moving scientific advances into day-to-day applications -- underscores NCCOS's emphasis on five key categories of "stressors" posing risks to coastal ocean ecosystems: climate change, pollution, invasive species, extreme events, and resource use. And that focus is key also as NCCOS scientists and partners address challenges facing the nation's coral reef ecosystems, National Marine Sanctuaries, estuaries and estuarine research reserves, and the coastal ocean.

This first NCCOS accomplishments report highlights just some of NCCOS's important activities from 2002. We hope it prompts further inquiries and still more partnerships in pursuit of preserving our coastal ocean resources. NCCOS is an open book, and we welcome your joining us to better help communities preserve the nation's inestimable coastal resources and values for our generation and those of Americans still to come. We welcome and appreciate your interest and involvement.

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Introduction

The National Centers for Coastal Ocean Science (NCCOS) was formed within the National Ocean Service in February 1999 to be the focus for coastal ocean science within NOAA. NCCOS provides national leadership in ocean, coastal, and Great Lakes science through internal and extramural research programs, linking the ecosystem science conducted within academia and NOAA laboratories with the day-to-day needs of coastal managers. NCCOS research activities provide information on the status of ecosystems and the causes and potential consequences of ecosystem changes, helping to evaluate potential effects of various management strategies. NCCOS uses an "Integrated Assessment"– a formal bridge between science and management– as its primary tool to integrate and make available the best existing scientific information. By using science to predict the potential consequences of different actions, NCCOS helps provide coastal managers with the information they need to make better and more informed decisions.

NCCOS is passionate about supporting NOAA's important environmental and economic missions by providing valuable scientific information. Its fundamental operating principles are to:

- Deliver high-quality science in a timely and consistent manner, using innovative and strong partnerships;
- Develop and maintain relevant research, long-term data collection and analyses, and forecasting capabilities to support NCCOS customers, stakeholders, and partners;
- Build capacity in the private, state, and local sectors by transferring technology and by providing technical assistance and knowledge to customers and partners; and
- Conduct anticipatory science to identify, assess and forecast the consequences of future stressors on coastal ecosystems.

NCCOS focuses its research efforts in five ecosystems– coral reefs, estuaries, national marine sanctuaries, national estuarine research reserves, and coastal waters. Research emphasis is placed on five sources of ecosystem stress: climate change, extreme natural events, pollution, invasive species, and land and resource use.

Currently, NCCOS is concentrating its research efforts on the protection of key endangered ecosystems such as coral reefs, estuaries and other areas that have been designated as marine reserves. It also is working to predict the impacts of chemical, biological and physical ecosystem changes in the

nation's coastal areas through a process known as ecological forecasting.

In 2002, NCCOS distinguished itself with an impressive list of research accomplishments, available online at http://coastalscience.noaa.gov/publications/welcome.html This document provides highlights of Fiscal Year 2002 accomplishments from each of NCCOS's priority research areas. For more information on other activities, see the NCCOS Web site at http://coastalscience.noaa.gov.

We value your interest, questions, and comments. Please feel free to contact us.

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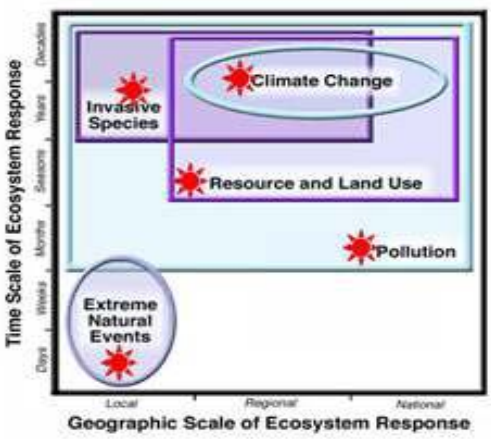
Examining "Stressors" – the Sources of Ecosystem Stress



Climate change, invasive species, pollution, extreme natural events, and land and resource use are major sources of coastal ecosystem stress. These stressors interact with each other across wide time and space scales, from hours to decades, and from small local areas to the entire planet.

Although each stressor can have a profound impact on its own, they often occur in concert. NCCOS studies the effects of these stressors on coastal and marine resources, both singly and in combination.

Climate change affects sea level, temperature, currents and stratification, storm frequency and intensity, and precipitation. Much uncertainty exists about how coastal zones and marine life will be affected by climate change. Observed climate impacts on today's coastal zones and marine life provide useful insights about potential longer-term impacts of climate change and variability.

Extreme natural events like hurricanes, coastal storms, floods, droughts, and harmful algal blooms can wreak havoc on coastal communities and produce profound ecosystem changes. Predicting these impacts aids emergency response and long-term planning in efforts to minimize these consequences.

Pollution affects marine ecosystems in a variety of ways, and it can persist long after the original source has been brought under control. Marine organisms can accumulate contaminants from water, sediments, or food in their body tissues. The resulting concentrations of contaminants can be many times higher than is found in the environment. Some pollutants like nitrogen are not toxic, but they can cause harm by stimulating biological activity or altering habitats. Over the past three decades, many industrial and chemical discharges have been regulated. However, nonpoint sources, particularly excess nitrogen from agricultural and suburban runoff and automobile and industrial air emissions, pose continuing risks to coastal areas.

Invasive species, the plants and animals brought to the U.S. from other countries or relocated to new areas from within the U.S., can damage or outcompete native plants and

animals. Invasives can change the community structure and cause substantial economic and environmental damage. Coastal managers need to be able to quickly and accurately predict the potential risk from nonindigenous species to determine proper mitigative actions.

Land and resource use produces changes resulting from society's increasing demands for food and space. America's coastal areas are densely populated. Some coastal populations exceed the population in the interior by fivefold. Development in coastal watersheds leads to more roads, boat docks, shopping malls, lawns and golf courses. The resulting impervious surfaces can lead to increased runoff because water cannot percolate into soils. This condition, in turn, degrades creeks, marshes and estuaries. In addition, fish populations can be reduced, and natural habitats may be damaged or destroyed. Abundances and health of marine plants and animals are altered.

The following sections highlight NCCOS's recent accomplishments within each stressor category. These research efforts support similar objectives and produce a clearer picture of the stressors affecting coastal ecosystems across the nation. Much of the research also reveals the possible causes of the stressors and the potential management actions available to offset environmental changes.

Climate Change

Higher temperatures, rising sea level and more frequent and severe storms are some potential impacts associated with climate change and variability. These conditions can have significant effects on coastal ecosystems. Estuaries and coral reefs are likely to be especially hard-hit because they are relatively shallow and already under stress from population growth and coastal development. Climate impacts are often hard to separate from other human-induced stresses to marine and coastal resources. Managing the potentially adverse effects of climate change will require a multi-disciplinary effort. NCCOS is studying the combined effects of human-induced and climate-related stresses to understand and predict how critical coastal ecosystems may respond. Highlights of these studies follow.

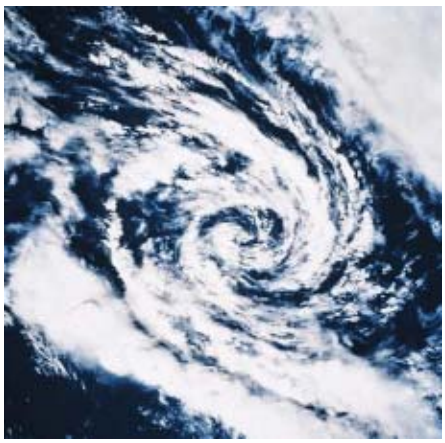
Warming Ocean Waters Linked to Shift in Tropical Fish Species Found off North Carolina
NCCOS research off the North Carolina coast shows a shift in recent decades toward more tropical fish species. Since 1977, warmer bottom-water temperatures along the subtidal continental shelf off Beaufort, N.C., have resulted in a dramatic shift towards tropical reef fauna. Recent re-sampling of areas, first sampled more than 20 years ago by NCCOS researchers, found that the total species composition of fish has become more tropical. Two families of fish and 28 species are newly identified in the area. A tropical sponge previously unrecorded at this latitude was also found. No new temperate fish were observed, and numbers of the most abundant temperate fish were down 2200%. These results may indicate the kinds of changes in species composition that accompany climate change. The area off Cape Hatteras, N.C., is likely to be a particularly sensitive area to these types of changes because southern warm water fish populations and northern colder water fish populations mix there. Fishery harvests already are reflecting changes in abundances of certain species.

Link Established Between Pacific Decadal Oscillation and Salmon Catch Size
NCCOS-sponsored Global Ocean Ecosystem Dynamics (GLOBEC) research confirms that a change in the Pacific Decadal Oscillation (PDO) sign corresponds to increases in both the nutrient supply and the krill population (a major component of coastal salmon diets) in Northeastern Pacific waters. The PDO is one example of natural variability that exists independently of human-induced climate change. It cycles between warm and cool periods, the result of ocean temperature anomalies in the northeast and tropical Pacific Ocean. The PDO index changed to cool conditions in 1998 after a period of warm conditions that began in 1976. The change in 1976 had far-reaching consequences to zooplankton and fish populations, resulting in sustained high salmon production in Alaska and reduced yields for the U.S. West Coast. Salmon population increased due to the greater food supply and lower predator populations (which migrate to warmer waters). The effects of climate change are likely to mimic certain aspects of natural climate cycles such as the PDO and its counterpart in the southern hemisphere. Findings from this study will help oceanographers and fishery scientists as they strive to understand the future impacts of climate change.

Research Defines New Role for Marine Phytoplankton That May Affect Climate
NCCOS researchers are examining the link between environmental oxidative stressors, factors that can increase intracellular oxygen to harmful levels, and feedback interactions between marine algae and climate. NCCOS' new theory is that dimethylsulfoniopropionate (DMSP) and dimethylsulfide (DMS) serve as parts of an antioxidant system in marine algae. The gas, DMS, provides a dominant source of sulfur to the marine atmosphere, affecting cloud formation and global climate. NCCOS, in collaboration with the State University of New York at Syracuse and the University of South Alabama, found that several oxidative stress factors (such as ultraviolet radiation, carbon dioxide limitations, high copper amounts) substantially increase DMSP and/or DMS in marine algal cultures. These results will help refine global climate change models, incorporating the often complex interplay between climate and marine biological communities.

Extreme Natural Events

Extreme natural events, such as hurricanes and harmful algal blooms (HABs), can wreak havoc on coastal communities. Hurricanes and tropical storms can cause beach erosion, change coastal circulation patterns, increase sediments in the water that blocks light needed by submerged aquatic vegetation, and increase pollutants into ecosystems. Hurricanes and tropical storms can also have long term effects, changing fisheries catch levels. HAB events can have serious consequences for human health, the environment, and local economies. Some species release extremely potent natural poisons, known as biotoxins, that can cause human illness and occasionally even fatalities. Others can result in massive mortality to wild and farmed fish, marine mammals, seabirds, and other protected species. Some produce massive "blooms" of cells that discolor large areas of water, such as Florida's toxic "red tides." Some nontoxic HABS also cause harm by irritating or damaging fish gills, causing murky water that shades out other marine plants, or reducing dissolved oxygen levels when they die off and decay. Better forecasting and monitoring methods will protect human health and lives, and reduce the trauma to coastal communities. Highlights of NCCOS work in this area follow.



New Technique Used to Assess Ecosystem Recovery from Hurricanes

A recent NCCOS study in the Pamlico-Albemarle Sounds of North Carolina demonstrates the ability of airborne laser-induced fluorescence measurements to detect and monitor ecosystem-wide changes in the distribution and concentration of chlorophyll and colored dissolved organic matter. These high-resolution data represent overall changes in the estuarine system more clearly than by sampling from any other platform. Pamlico Sound, which separates North Carolina's Outer Banks from the mainland, is a highly productive lagoonal estuary that is often affected by hurricanes. After a series of three hurricanes within 45 days in 1999, the system was severely disrupted. Chlorophyll levels dropped to 0.1 of normal levels. Chlorophyll in the Pamlico-Albemarle Sound returned to equilibrium within a year. Findings from this study are relevant to predicting the duration of extreme event effects on lagoonal ecosystems, and in predicting secondary effects, such as fisheries production.

New Technology Developed to Measure HAB Toxins in Living Animals

NCCOS and researchers from AgResearch Ltd. of New Zealand have developed a new technology that can test for low concentrations of toxins in living tissue during the first states of an HAB outbreak. Using this technology, researchers can measure the level of brevetoxin, which is produced by the red tide alga *Karena brevis*, in aquatic laboratory animals at concentrations 10 times below those that produce symptoms. In addition, the technology allows for testing of the toxin within just two days of exposure. Although the technology is still being evaluated, it may help researchers predict the adverse consequences of red tides and toxic events in protected species earlier than before.

New Field Test Used to Detect Domoic Acid Toxin in Olympic Peninsula Clams

NCCOS's Monitoring and Event Response for Harmful Algal Blooms (MERHAB) program and its regional counterpart, the Olympic Region Harmful Algal Bloom (ORHAB) program, are assisting communities on Washington State's Olympic Peninsula with an array of promising field monitoring technologies to warn of impending domoic acid outbreaks and to speed detection and response. On the West Coast, particularly on Washington's Olympic Peninsula, the economic consequences of domoic acid on fisheries and ecosystem health have been severe. High levels of domoic acid in 1998 closed the razor clam season for an entire year, at an estimated cost of $12 million in lost recreational spending and $7 million from the tribal commercial harvest. New field test kits provide for local testing for the presence of toxins in shellfish tissue, eliminating the need to transport samples to a distant laboratory. The tests produce results in just a few hours. Managers from the Washington State Department of Health say that as a result of access to data and expertise available only through the ORHAB partnership, the state has increased its confidence in predicting shellfish safety in the region while requiring 40 percent fewer samples to make determinations. Additionally, HAB monitoring advances through ORHAB have reduced instances of unnecessary beach closures, thus improving public confidence in state resource management agencies, providing better protection for public health, and benefitting the economies of struggling Olympic Coast beach communities. With additional testing, this technology may also be adapted to screen for the toxins associated with paralytic shellfish poisoning, a HAB-related illness of major concern to the region's shellfish growers and a serious health threat to Pacific Coast communities stretching from California to Alaska.

Pollution

Nutrient overenrichment, or nutrient pollution, has been recognized as a problem in freshwater systems for many years, but concern about the widespread occurrence of eutrophic conditions in estuarine systems has grown since the 1970s. Nutrient pollution now represents the most widespread pollution problem facing U.S. coastal waters. It is the common thread that links an array of problems along the nation's coastlines, including eutrophication, harmful algal blooms, "dead zones" where oxygen levels fall too low to support aquatic life, massive fish kills, loss of seagrass and kelp beds, certain shellfish poisonings, coral reef destruction, and marine mammal and seabird fatalities.

Various chemical and biological contaminants are also of concern. These include naturally occurring chemicals, such as trace metals and oils, which are present in higher quantities due to human activities, and compounds such as pesticides and pharmaceuticals that do not exist in nature. Toxic pollutants of particular concern are those that are widespread and persistent in the environment, those that tend to accumulate in biological tissues, and those producing biological effects at extremely low concentrations. NCCOS is conducting research on all forms of pollution, emphasizing non-point source pollution. Highlights of NCCOS work in the area follow.

Louisiana Hypoxic Zone Size Linked to Nutrient Load

The National Ocean Service (NOS) has been assessing the size, extent and consequences of the hypoxic area off the Mississippi River Delta since 1985. In 2002, an NCCOS-supported Hypoxia Assessment study found that the "dead zone" off Louisiana and Texas had grown. At that time, it covered an area in the Gulf of Mexico larger than the State of Massachusetts. The zone stretches from the Mississippi River Delta along the Louisiana coast to the upper Texas coast near Galveston. In some places it is located close to shore, while in other areas, like the coast of Cameron, La., it is as far as 60 miles offshore. Hypoxia results when oxygen consumption, primarily through decomposing organic material, exceeds oxygen production. Organic matter can be supplied from external sources, such as river inflow, or can be produced within the system through algal blooms stimulated by nutrients. The size of the Gulf of Mexico hypoxic zone is related to the amount of excess nutrient runoff, particularly nitrogen, from the Mississippi-Atchafalaya River Basin.

Fish/Shrimp Distributions Reveal Hypoxic Zone Structure

NCCOS-supported research on fish and shrimp distributions on the inner continental shelf off the coast of Louisiana in July 2002 revealed the detailed structure of the Gulf of Mexico hypoxic zone. Researchers conducted a fine-scale survey of bottom water oxygen along with fish and shrimp distributions over a 6,000 sq. km. sampling region off the Louisiana coast. The sampling revealed detailed structure of the hypoxic zone, showing the edges of the zone to be complex on both the seaward and shoreward sides. An area of oxygenated water within the hypoxic zone

corresponded to a shallow, wind-mixed shoal. The edges of the hypoxic zone, as well as oxygenated interior regions, appear to be used by a variety of species. During the course of the survey, more than 150 species were collected. In general, species diversity and biomass were substantially lower within the hypoxic region. Atlantic croaker and brown shrimp, the focus of the study, were found both inshore and offshore of the hypoxic zone, across a range of oxygen conditions, but rarely within it. These results complement those of larger-scale mapping efforts supported by NCCOS and designed to determine the annual spatial extent of the entire hypoxic region and the environmental consequences.

New Model Predicts Risk to Marine Mammals from Organochloride Pollutant Exposure

NCCOS scientists have developed an innovative way to assess risks to marine mammals from organochlorine pollutant exposure. A 1987-88 bottlenose dolphin mortality event along the U.S. Atlantic Coast prompted concerns over the overall health status of these animals. The NCCOS risk assessment approach integrates data on tissue concentrations of polychlorinated biphenyls (PCBs) from live-captured bottlenose dolphins (*Tursiops truncatus*) with a "surrogate dose-response model" to predict health risks to marine mammals. The model estimates reproductive effects and uncertainties associated with the predictions. Risk analyses conducted for dolphin populations near Beaufort, N.C., Sarasota, Fla., and Matagorda Bay, Texas, indicate a high likelihood that the animals' reproductive success is being severely impaired by chronic exposure to PCBs. This information is needed in order to formulate a management strategy for these animals as required by law.

New Data Added to Growing Historical Database on Estuarine Contaminants

Data from NCCOS's National Status and Trends Program, the Mussel Watch Program, and regional contaminant surveys have increased scientists' understanding of contaminant levels in U.S. estuaries. *Waters of the Carolinas*, published in 2002, is the seventh area for which a regional report has been produced. Data from the Mussel Watch program, which measures spatial scales and temporal trends in coastal contamination, are now available from 1986 to the present. The cumulative data are still insufficient to discern trends over decadal scales, but numerous analyses have been performed on the current database to determine temporal changes in levels of pesticides, industrial chemicals, trace metals, and other selected contaminants. These analyses indicate that at most sites, levels of environmentally persistent contaminants, such as polychlorinated biphenyls (PCBs), have not decreased even though their use has declined markedly over the past two decades. *Contaminant Trends in U.S. National Estuarine Research Reserves*, also published in 2002, summarizes six years of chemical contaminant data for Mussel Watch sites located in National Estuarine Research Reserves.

Lab Tests Show Lower Reproduction Levels for Endosulfan-treated Shrimp

NCCOS scientists have found that endosulfan is rapidly accumulated and concentrated from water by both phytoplankton and zooplankton, and that chronic exposure to the pesticide endosulfan delays reproduction in grass shrimp (*Palaemonetes pugio)*. These shrimp are a key estuarine food source for commercial fisheries. Endosulfan, which is used on a variety of vegetable crops, has been linked to fish and shellfish kills in estuarine waters of the southeastern United States. In the laboratory, endosulfan-treated grass shrimp showed a 30 percent reduction in potential reproduction during the course of the study. The research suggests the possibility of

broader population impacts for similar invertebrate species exposed to this chemical in the environment. These findings are being used by U.S. Environmental Protection Agency and state agencies in assessing ecosystem risks from this commonly used pesticide.

Review of Endocrine Disruption in Fish Finds No Clear Indication of Large-Scale Population Harm

A newly completed NCCOS assessment of current scientific research provides an overview of the incidence of endocrine disruption in both freshwater and saltwater fishes. This assessment points to "no clear indication" that large numbers of fish are being seriously harmed, but cautions that more work is needed to confirm that conclusion. The assessment generally concludes that the scientific community finds no indication that overt endocrine disruption in fish is a ubiquitous environmental problem. Rather, it finds higher levels of endocrine disrupters near major pollution sources such as sewage treatment plants, pulp and paper mills, some industrial plants, and in areas characterized as having high organic chemical contaminants. In areas of heavy industrial activity, effects to fish include reduced levels of estrogens and androgens, and reduced gonadal development, possibly linked to polycyclic aromatic hydrocarbons, polychlorinated biphenyls, and dioxins. These effects may impact future fish reproductive capacity. Since the effects appear to be localized near particular land-use activities, these results suggest the value of specific targeting of these point sources for remediation.

Invasive Species

Non-native plants and animals introduced from other countries or relocated to new areas from within the United States threaten the fabric of coastal ecosystems and cost millions of dollars to manage and control. U.S. marine and coastal environments are particularly susceptible to risks posed by non-native species introductions, as species composition can change in unpredictable ways and often dramatically. Already stressed fisheries face added risks. Stimulated by the rapid global expansion of trade, transport, and travel, invasive species and their costs to society are increasing at an alarming rate. After habitat destruction, biological invasion is considered to be the second largest cause of loss of native species and biological diversity. In the U.S. alone, approximately 50,000 exotic species are known to exist. The major environmental damages, losses, and control measures for invasive species cost the nation an average of $138 billon per year. NCCOS invasive species research focuses on identifying invasive species, warning of new sightings, and predicting the likelihood that a particular species might become invasive. Highlights of these studies follow.

Committee Issues Plan to Control Green Crab Invasion

NCCOS has worked with the Green Crab Management Committee to develop a draft plan to control the European Green Crab invasion that continues to plague U.S. waters. The European green crab (*Carcinus maenas*) is native to northern European coastal waters. Since the early 1800s, when it first appeared on the U.S. East Coast, it has successfully extended its range as far north as Nova Scotia and as far south as Maryland. Green crabs are known to be voracious predators. Although they prefer bivalves and other infaunal organisms, they also prey on other crab species. Green crabs inhabit a variety of habitats and environmental conditions, and appear to be responsible for broad-scale changes in invertebrate communities, including among commercially important species such as scallops. Green crabs are probably not the primary culprit in the scallop decline, but they are accused of being "accessories to the crime." Green Crab Committee membership represents state, federal, tribal, and scientific interests. The committee's plan contains extensive background information on the evolution of this problem, including mechanisms of introduction and spread, population characteristics, and ecological and economic impacts. The committee has identified phased implementation and funding plans for four management options.

Alien Species Early Warning Pilot

NCCOS and its partners are piloting an early warning system for invasive species in Hawaii's marine and estuarine coastal areas. The system uses a searchable database of U.S. native coastal species and a user-friendly Web interface. With the addition of data from future regional projects, the Hawaii pilot can evolve into a national early warning system that will help resource managers quickly identify new species introductions in U.S. waters. Early detection of the presence of new alien species, coupled with concerted action, may mitigate the impacts of these new species on native populations before these alien species become established beyond the point of introduction. The early warning system will allow natural resource managers time to prepare and implement mitigation procedures.

NCCOS Teams with Local Groups to Remove Alien Seaweed from Waikiki
The NCCOS-sponsored Hawaii Coral Reef Initiative Research Program (HCRI-RP) and local partners teamed up for the second year in a row to clear alien algae from the beach and swimming channel near the Waikiki Natatorium. More than 70 volunteers removed more than 5,000 pounds of the alien seaweed *Gracilaria salicornia* from the area in less than five hours. Since the cleanup on Sept. 21, 2002, a total of 11,800 pounds of *Gracilaria salicornia* has been cleared out of the trench near the facility. The goal of the cleanup is to help reduce the amount of alien seaweed and eventually restore the reef to a more natural state. Hawaiian Earth Products, a local green-waste recycling company, is testing the seaweed for use as compost.

Land and Resource Use

Today's coastal residents use more land, drive more, boat more, and consume more resources than their predecessors did even 30 years ago. The same is true elsewhere in the nation, but the effect on coastal areas is exaggerated because the population there is denser. Wetlands are being converted to residential areas, golf courses, and parking garages at an unprecedented rate. Runoff from suburban lawns and parking lots ends up in nearby creeks and estuaries. A combination of factors, including poor water quality, overfishing, coral bleaching associated with climate change, and even boat groundings, are causing widespread damage to coral reefs and submerged ocean grasses. NCCOS's research on the effects of land and resource use on marine ecosystems will help coastal managers make more informed choices about coastal development options. This research focuses primarily on estuaries, seagrass, and coral reefs, Highlights of NCCOS research in these areas follow.

Estuaries

Estuaries, the coastal zones where rivers join the sea, are uniquely productive natural systems. In this rich interface of marine and terrestrial worlds, fresh and salt waters merge in an ebb and flow ruled by the tides. Here, abundant life is created and nurtured, enriching not only the oceans but also the economies of coastal communities. Estuaries and estuarine-like habitats, such as the Great Lakes, are composed of many habitat types, including salt marshes, oyster reefs, swamps, and seagrass meadows. Estuaries provide critical habitat for many species of fish, shellfish, and seagrasses. They also serve as nursery and spawning grounds for a number of endangered and threatened species.

Impacts of Methylmercury in the Everglades

The Everglades restoration project will lead to increased freshwater flows throughout the region, raising the possibility that methylmercury produced in the Everglades or the mangrove transition zone may increase levels in Florida Bay. Monitored concentrations of mercury in water, sediments, and fish from Florida Bay show the highest mercury concentrations in the mangrove transition zone where freshwater first mixes with saline coastal waters. Concentrations appear to correlate with seasonal increases in freshwater flows from the Everglades. Human exposure could increase if fish in the Florida Bay become contaminated. The altered flow regime may engender trade-offs in how best to protect people and wildlife in both the terrestrial and coastal aquatic ecosystems of South Florida. NCCOS scientists in Beaufort, N.C., are continuing their extensive partnership with South Florida water quality professionals to track potential increases in methylmercury that could result from the Everglades restoration project.

Retention Pond Research Addresses Growing Coastal Population Pressures
NCCOS researchers are exploring cost-effective ways to better manage retention ponds used along the southeastern Atlantic Coast to catch runoff from golf courses and other coastal development. The research will help coastal landscape planners and natural resource agencies minimize impacts from inevitable coastal development. Golf courses are increasingly being built along the coasts, and little is known about the potential impacts of golf courses and other turf management practices on estuarine systems. Estuaries not flushed by inflow from rivers are particularly vulnerable to contamination from adjacent commercial and residential development. NCCOS researchers launched their investigations with an in-depth look at two residential retention ponds and a golf course pond on South Carolina's Kiawah Island. The research is benefitting significantly from recent advances in technology, such as the use of digital elevation model basemaps and landcover maps of affected watersheds, the use of geographic information systems statistical models to characterize relationships between land uses and nutrient loadings, and hydro models that predict how water and waterborne contaminants will flow through an ecosystem. With these tools in hand, researchers have simulated nutrient and coliform loadings to receiving estuaries following major rain events. They plan to use their findings to shape best management practices that resort community managers can use to avoid unintended nonpoint source pollution from their sites into nearby coastal estuaries.

Seagrasses
Seagrasses form the basis for highly productive ecosystems by binding sediments, buffering waves and currents, cleansing nutrients in the water column, and providing food and shelter for other marine organisms. Although their ecosystem value is well recognized, many aspects of their distribution, population dynamics, and restorative abilities are not well understood. NCCOS provides published guidance and expert opinions on all aspects of seagrass restoration, injury assessment, and restoration technology.

NCCOS Helps Recoup Damages from Florida Keys Marine Sanctuary Groundings
NCCOS played a key role in NOAA's efforts to recover compensation for damages to seagrass beds and coral reefs caused by vessel groundings in the Florida Keys National Marine Sanctuary. Fines imposed on owners of grounded vessels raise public awareness of the damages caused by boat groundings and are expected to reduce the growing number of groundings in the Florida Keys. The "Mini-312" Program, authorized under Section 312 of the National Marine Sanctuaries Act, provides for an immediate response to vessel groundings. When one occurs, NOAA's Damage Assessment and Restoration Program sends a team to document the incident and collect the data needed to pursue legal action. NCCOS provides scientific expertise to ensure the validity of the scientific data in court proceedings. Recoveries have ranged from $5,000 to $45,000, averaging $25,000.

Actively Fished Spiny Lobster Traps Have Little Impact on Seagrasses in the Florida Keys
NCCOS researchers completed a gear impact experiment in the Florida Keys on the effect of

lobster traps on seagrass beds. They concluded that within the limits of their testing parameters, standard fishing practices would not result in a significant injury to seagrass beds in the Florida Keys. However, traps must be recovered within a six-week period, after which injury to seagrass beds is likely.

Coral Reefs

Coral reefs are among the most valuable and spectacular places on Earth and are some of the most productive and diverse marine ecosystems. NCCOS is working with others to understand the extent of, and the reasons for, the decline of coral reef ecosystems, and to provide managers with better tools to protect them. NCCOS is leading an investigation to map the distribution of coral reefs throughout U.S. states and territories, information that is not currently available and is critical to conserving these areas.

Coral Reef Mapping Milestone Reached

NCCOS has completed mapping the coral reef ecosystem surrounding Puerto Rico and the U.S. Virgin Islands, the first area to be mapped under the U.S. Coral Reef Task Force's *National Action Plan to Conserve Coral Reefs*. Local and federal agencies dealing with these reefs now have spatially explicit information on the distribution of natural resources within their jurisdictions. Conservation groups can more effectively target critical habitats and areas of particular concern. Commercial interests can select areas best suited to meeting economic objectives and can integrate environmental concerns into site selection. Researchers have a spatial framework within which to conduct habitat studies across a range of spatial scales. Similar coral ecosystem maps and related information are currently being prepared for Hawaii and the U.S. Pacific Territories.

Coral Reef Ecosystem Health Report Card

Under the auspices of the U.S. Coral Reef Task Force and as required by law, NCCOS released the first assessment on the condition of U.S. coral reefs, citing environmental pressures that pose increasing risks to reefs. The interagency report highlights the increasing degradation of shallow-water coral reefs near inhabited coastal areas, while distant reefs, where fishing pressure is low, remain in near-pristine condition. Coastal pollution, runoff, ship groundings, diseases, climate change, trade in coral, and destructive fishing practices are among the top-ranked threats. The report establishes a baseline for tracking changes through time, one of the goals set by the U.S. Coral Reef Task Force's *National Action Plan to Conserve Coral Reefs*.

Northwestern Hawaiian Island Reefs Assessment

NCCOS completed a Northwestern Hawaiian Islands (a coral reef ecosystem reserve) reef assessment and found the coral reef ecosystem to be surprisingly pristine and diverse. *Coral Reef Ecosystems of the Northwestern Hawaiian Islands* is a 50-page color booklet describing the results from the Northwestern Hawaiian Islands Reef Assessment and Monitoring Project. Expeditions to the Northwestern Hawaiian Islands revealed that this ecosystem is pristine and home to numerous reef animals and plant species, one-fourth of which are unique to Hawaii. Additional significant findings are described in the report.

Fisheries

Fisheries managers strive to balance competing uses of ocean resources. Despite efforts to manage fish stocks for sustainable use, many stocks are in decline. A 2000 NOAA fisheries

assessment found that of the 905 fish stocks in the U.S. Exclusive Economic Zone, 72 are overfished, five are approaching overfished status, and 210 are not overfished. Those numbers leave 618 stocks for which the status is virtually unknown. NCCOS is investigating how changes in land use and management patterns, population growth, habitat quality, and other environmental factors affect fisheries.

Multiple Paternity Linked to Loggerhead Survival
New findings by NCCOS researchers provide hope for the recovery and survival of endangered loggerhead sea turtles. An NCCOS investigation found multiple paternity to be common in sea turtle nests. Of 70 clutches analyzed in Melbourne Beach, Fla., 22 had more than one father, and six had more than two fathers. Multiple paternity in loggerheads may increase the effective population size in depleted populations and is likely to be important in maintaining genetic diversity.

Otoliths from Spawning Females Used to Determine King Mackerel Stock Composition
NCCOS and National Marine Fisheries Service (NMFS) investigators used otolith-shape analysis to estimate the stock composition of king mackerel taken in the mixed-stock winter fishery off southeastern Florida. Fishermen often take fish from more than one stock (biological population). Fishery management plans are stock specific. So it is important to be able to tell from which stock a fish was removed. Otoliths from spawning females were analyzed, and a model for stock composition developed, based on the stock-specific morphology of otoliths. When the model was applied to samples from the 1996-97 mixed-stock fishery, more than 99 percent of the fish taken were estimated to be from the Atlantic stock, quite a different picture from previous assumptions. Knowing which fish stock is being affected by the fishery will considerably improve the management of these stocks, particularly if regular sampling can be conducted of spawning aggregations and the mixed-stock fishery. If all the fish are being removed from primarily one stock, fishing regulations could be modified to reflect the true fish population removal.

Wilmington Harbor Project Found to Have Limited Fisheries Impact
NCCOS researchers investigated the effects of underwater explosive detonations on larval fishes to determine potential risks to Cape Fear River fish populations from the Wilmington Harbor Project blasting. Controlled experiments exposed larvae to explosive shockwaves that varied in magnitude, impulse, and energy flux. Histopathology was used to assess the trauma suffered by larvae. Mortality models developed from this research were coupled with data on the concentration of larvae in the portion of the river where blasting would take place, and with field measurements of shockwaves from production blasts, to estimate larval mortality. Results suggest that nearly 820 million larvae could be injured or killed during the project's 5- to 7-year duration. While that is an appreciable number of larvae, it represents only 2 to 3 percent of the larvae in the affected area over the life of the project. Based on this assessment, NCCOS advised the U.S. Army Corps of Engineers, Wilmington District, that the impact of project blasting was unlikely to have population-level effects, and offered guidance on the appropriate shockwave monitoring locations. The effort is expected to reduce costs to the $377 million project by obviating the need for ongoing larval fish monitoring.

First-Year Survey of Dry Tortugas Ecological Reserve Shows Little Recovery
One year after the Dry Tortugas obtained Reserve status, an NCCOS assessment found little

evidence of recovery from shrimp trawling pressures. In July 2001, the Dry Tortugas No-take Ecological Reserve was designated to protect the diverse marine life and lush coral reefs in the westernmost waters of the Florida Keys National Marine Sanctuary. The NCCOS assessment found little evidence of change in coral reef resources one year after they were protected as part of the Reserve. Few changes were observed at the reef-sand interface, particularly in the spiny lobster population that was expected to begin rebounding. Gear impact studies in the northern boundary of the Tortugas Ecological Reserve found little recovery from past trawling effects. Drift camera and beam trawl surveys of past versus present shrimp trawling areas of the famous Tortugas pink shrimp fishery detected heavy trawling activity right at the Reserve boundary. Sites located 2 km inside the boundary had only slightly more shrimp than those outside, and little visual difference existed in benthic community structure. Sampling began two years before implementation of the Reserve. The NCCOS survey effort marks the one-year, post-implementation survey. Future surveys will to continue to monitor the effects of Reserve status on coral reef resources.

Geotextile Tested for Oyster Reef Restoration

NCCOS conducted research in North Carolina and the Chesapeake Bay on the use of geotextile for oyster reef restoration. Geotextile is used to construct geotubes, which are filled with clean dredge material. Once filled, these structures become very rigid, producing a substrate that acts as a surrogate for natural oyster shell in oyster settlements, and, potentially, in the construction of artificial oyster reefs. Substitute materials are needed to offset a scarcity of oyster shells**.**

Marine Forensics Assistance Supports 21 Federal and State Prosecutions

NCCOS' Marine Forensics Branch links science, law enforcement, and prosecution to deter crimes damaging the coastal ocean environment. The NCCOS effort provides scientific support to NOAA and other enforcement agencies including the U.S. Fish and Wildlife Service, U.S. Customs, and state wildlife law enforcement. Cases submitted for analysis primarily involve the Convention on International Trade in Endangered Species (CITES), the Endangered Species Act, the Magnuson-Stevens Fishery Act, and/or Lacy Act violations. Determinations usually involve species identification, minimum number of individuals, and cause of death related to human and/or fisheries interactions. These determinations are used to prosecute illegal activities and apply also to fish management and seafood industry practices. In 2002, NCCOS provided forensic assistance on more than 21 federal and state cases, including a case in which a California woman was sentenced to six months in prison for smuggling 2,900 endangered Olive Ridley sea turtle eggs into the United States from El Salvador. The protected eggs fetch $5 each on the black market.

Coastal and Estuarine Data Rescue Efforts Begun

NCCOS has established an innovative project, Coastal and Estuarine Data/Document Archaeology and Rescue (CEDAR), which combines scientific expertise with library science skills to preserve irreplaceable data and documents. Numerous significant documents and reports related to the marine environment have never been published, and therefore, are not available to the public, the scientific community, and scholars. These unique documents and data are

important because they define the state of the marine environment in the past. Thus, they are essential for comparing past and present conditions to estimate the rate of degradation of natural resources. The initial NCCOS effort focused on data for the South Florida ecosystem.

Integrated Assessments

NCCOS research on environmental stress factors provides basic information needed to develop integrated assessments. These assessments provide information for managers and scientists to evaluate an ecosystem, develop options for future action, and identify gaps in the understanding of the issues. Integrated assessments typically have four parts: (1) a description of the ecosystem, (2) assessment of its current condition, (3) forecasts of its future ecological health using current management strategies, and (4) evaluations of alternative strategies and their potential impacts.

Integrated assessments also are vital to ecological forecasting, which is the science of predicting the impacts of physical, chemical, biological, and human-induced change on ecosystems and their components.

In FY 2002, NCCOS completed an integrated assessment on an invasive species problem: An Integrated Assessment of the Introduction of Lionfish *(Pterois volitans)* to the Western Central Atlantic Ocean.

First Integrated Assessment Completed on Introduction of Lionfish to the Western Central Atlantic Ocean

Beautiful but dangerous lionfish (*Pterois volitans*), venomous coral reef inhabitants native to the Indo-Pacific, are turning up in the waters off the southeast U.S. coast. Adult lionfish have been observed from Miami, Fla., to Cape Hatteras, N.C. Juvenile lionfish were observed off the North Carolina coast, and off Long Island, N.Y., and Bermuda. The conclusion is that lionfish are now established and reproducing along the southeast U.S.

Currently, no management actions are being taken. A small research effort is underway, funded by both NCCOS and the National Marine Fisheries Service. The researchers are examining the thermal tolerance of lionfish to predict potential range along the U.S. East Coast. Under a scenario of no management actions and limited research, three outcomes are likely:

- Lionfish population abundance will increase;
- As a result of increasing abundance, the effects on the southeast U.S. continental ecosystem will become more noticeable; and
- Eventually, lionfish stings will occur in the wild along the southeast U.S. coast.

To prevent these outcomes, experts will need to reconcile several trade-offs. For example, restricting the import of marine aquarium fish would increase aquarists' demand for native fishes. Aquaculture may play a role, but research and development costs associated with cultured species must be considered. In addition, escape of fishes from aquaculture facilities is a common

way in which nonindigenous marine fish are introduced. Education and outreach efforts should be priorities. Home aquarists, the aquarium industry, fish collectors, aquaculture operations, divers, fishermen, life guards, boat captains, and health-care providers need to be educated about the issue of marine fish introductions, including the risks involved and how to treat associated medical problems.

Finally, an introduced species often disperses via natural mechanisms, further extending its introduction. Efforts to restrict the introduction of marine fish could fail if these efforts do not consider the natural dispersal of a species following its introduction. As a result, management efforts must be implemented on a regional basis and across political jurisdictions.

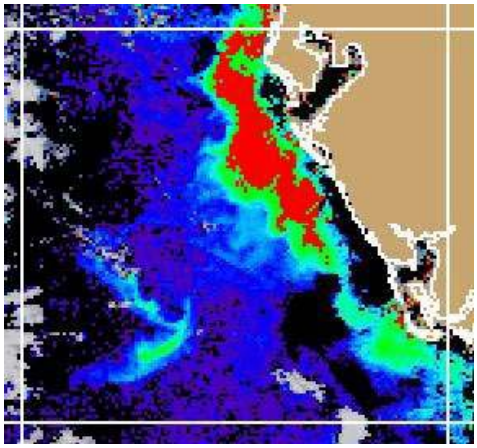
Ecological Forecasting

Ecological forecasts are powerful tools that help coastal managers predict the impacts of human activities and natural processes on the nation's ocean and coastal environments. Ecological forecasting helps managers answer "what if" questions and determine the best methods to meet environmental and societal needs before an event occurs.

One of NCCOS's most innovative products allows scientists to successfully predict harmful algal bloom (HAB) landfalls. NCCOS is currently expanding HAB research and forecast capabilities to develop ways to forecast bloom development, persistence, movement and toxicity. When there is a clear understanding of how physical and biological processes interact to prompt HAB development, reliable models can be developed to identify systems and areas potentially susceptible to outbreaks. That capability could help monitoring agencies and health departments develop rapid responses to safeguard public health, local economies and fisheries. Further, identifying conditions in which blooms are likely to occur will also permit management of specific environmental factors to reduce bloom impacts.

NCCOS is currently working on other ecological forecasts regarding the pink shrimp harvest of North Carolina, the extent of the Gulf of Mexico hypoxic zone, trends in sediment contamination, effects of freshwater inflow on Apalachicola Bay oyster mortality, coral bleaching, Pacific Northwest razor clam domoic acid concentrations, and South Carolina storm-related shellfish closures.

Coastal Community Bulletins Predict HAB Landfall



In FY 2002, NCCOS released 13 HAB bulletins predicting *Gymnodium breve* landfalls in the Gulf of Mexico. The dinoflagellate *Gymnodium breve* produces toxic substances that can cause neurotoxic shellfish poisoning. Risks to people include respiratory irritation and severe gastrointestinal and neurological symptoms, although full recovery usually occurs within seven days. NCCOS scientists, assisted by other NOAA partners, can locate blooms by assessing surface chlorophyll concentrations detected by satellite imagery and verified by data from ships. Then, they apply their understanding of the biological and physical aspects of bloom dynamics and transport, and conditions conducive to HAB development, to predict when and where HABs will affect coastal communities. The primary users of the Gulf of Mexico HAB Bulletin are the agencies with management responsibilities (e.g., Agriculture, State Health, Fish & Wildlife). The bulletins are also received by 17 non-regulatory users including municipalities, businesses, and the research community. These predictions help resource managers, industry, and the public by providing advance warnings of a HAB event and its potentially harmful impacts, and by helping to determine beach closures.

The NCCOS Organization

NCCOS consists of five Centers, each of which has a unique set of capabilities and research expertise in a broad range of ocean and coastal issues. The five Centers are:

Center for Coastal Monitoring and Assessment (CCMA)
301-713-3028
http://ccma.nos.noaa.gov

The Center for Coastal Monitoring and Assessment (CCMA), located in Silver Spring, Md., is responsible for producing and updating ecosystem status reports that incorporate the results of current scientific research on how and why ecosystems function as they do. Major research areas include the National Status and Trends program, Mussel Watch program, harmful algal bloom remote sensing and bulletins, and other programs that monitor and characterize the status of ecosystem health.

Center for Environmental Health and Biomolecular Research (CCEHBR)
843-762-8500
http://www.chbr.noaa.gov

The Center for Environmental Health and Biomolecular Research (CCEHBR) in Charleston, S.C., conducts research to improve ecological indicators, emphasizing the application of chemical and biochemical techniques. Major research areas involve marine toxins and harmful algal blooms, biochemical indicators of marine mammal health and corals, land use and the presence of chemical contaminants in the marine environment, and genetic characterization of fish and other marine biota. The affiliated Oxford Cooperative Laboratory, located in Oxford, Md., specializes in marine resource diseases.

Center for Coastal Fisheries and Habitat Research (CCFHR)
252 -728-3595
http://shrimp.ccfhrb.noaa.gov

The Center for Coastal Fisheries and Habitat Research (CCFHR) in Beaufort, N.C., focuses on understanding marine habitats and aquatic communities to improve ecological forecasts of management actions. This includes converting research results into quantified estimates of natural fish mortality, growth, and reproduction parameters for use in population assessments. Research results are applied to habitat restoration, predicting fisheries response to exploitation, and biological productivity and cycling of contaminants along the southeast U.S. coast and in the Gulf of Mexico. The Kasitsna Bay Laboratory, located in Alaska's Kachemak Bay system, is

affiliated with CCFHR.

Center for Sponsored Coastal Ocean Research (CSCOR)
301-713-3338
http://www.cop.noaa.gov

The Center for Sponsored Coastal Ocean Research (CSCOR), located in Silver Spring, Md., supports NOAA's ecosystem and resource responsibilities by collaborating with other federal agencies, universities and states and funding an extensive research program. CSCOR manages a competitive, peer-reviewed, interdisciplinary research program focused on long-term, large-scale ecosystem studies aimed at improving the condition of the coastal ocean. Major research areas include coastal fisheries ecosystems, cumulative coastal impacts, and harmful algal blooms and eutrophication.

Hollings Marine Laboratory (HML)
843-762-8737

Hollings Marine Laboratory (HML) in Charleston, S.C., is a newly established multi-institutional, multidisciplinary laboratory focused on the coastal ocean ecosystems and human health. Major research areas include environmental/analytical chemistry, marine genomics, contemporary use of pesticides, ecotoxicology, proteomics, and aquaculture production and disease. Co-located at the facility are representatives of the National Institute of Standards and Technology, the University of Charleston, the South Carolina Department of Natural Resources, and the Medical University of South Carolina.

NCCOS Headquarters (NCCOS HQ)
301-713-3020
http://coastalscience.noaa.gov

NCCOS Headquarters (NCCOS HQ) is located in Silver Spring, Md. Headquarters operations include administrative management and coordination of the activities conducted at the five Centers, all of which are integrated to address national coastal priorities. Staff also conduct pilot projects to test new approaches to specific problems and provide cross-NOAA and interagency representation on coastal science and management issues.